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Moving Charges and Magnetism

Ncert Exercise

Ans1) No of turns in the coil = 100

Radius = 0.08 m

Current flowing in the coil = 0.4 A.

As we know,

$$|B| = \frac{\mu_0}{4\pi} \frac{2\pi n I}{r} , \mu_0 = 4\pi \times 10^{-7} \, T m A^{-1}$$

$$|B| = \frac{4\pi \times 10^{-7}}{4\pi} \times \frac{2\pi \times 100 \times 0.4}{0.08}$$

$$= 3.14 \times 10^{-4} \, T$$

Ans2) $I = 35A$

$r = 0.2 \, m$

$\mu_0 = 4\pi \times 10^{-7} \, T m A^{-1}$

$$B = \frac{4\pi \times 10^{-7}}{4\pi} \times \frac{2 \times 35}{0.2} = 3.5 \times 10^{-5} \, T.$$

Ans6) $l = 0.03 \, m$

$i = 10 A.$

$B = 0.27 \, T$

$\theta = 90^\circ.$

$F = Bil \sin\theta$

$= 0.27 \times 10 \times 0.03 \times \sin 90^\circ$

$= 8.1 \times 10^{-2} \, N$

Ans7) $I_A = 8A$

$I_B = 5A.$

$r = 0.04m$

$l = 0.1m.$

$B = \frac{\mu_0 2 I_A I_B l}{4\pi r.} = \frac{4\pi \times 10^{-7} \times 2 \times 8 \times 5 \times 0.1 \times 100}{4\pi \times 4}$

$= 2 \times 10^{-5} N.$

Ans8) $l = 0.8 m$

Total no. of turns in the Solenoid, $N = 5 \times 400 = 2000.$

Diameter of Solenoid = 1.8cm = 0.018 m.

$I = 8A.$

$B = \frac{\mu_0 N I}{l.} = \frac{4\pi \times 10^{-7} \times 2000 \times 8}{0.80}$

$= 8\pi \times 10^{-3} = 2.512 \times 10^{-2} T$

Ans11) $B = 6.5 G = 6.5 \times 10^{-4} T.$

Speed of e^- ⇒ $v = 4.8 \times 10^{6} m/s.$

Charge on e^- ⇒ $e = 1.6 \times 10^{-19} C$

$m_e = 9.1 \times 10^{-31} kg.$

Magnetic force exerted on e^- = $evB\sin\theta$

Centripetal force on e^- = $\frac{mv^2}{r.}$

A/Q

$evB\sin\theta = \frac{mv^2}{r.}$

$r = \frac{mv}{evB\sin\theta} = \frac{9.1 \times 10^{-31} \times 4.8 \times 10^{6}}{6.5 \times 10^{-4} \times 1.6 \times 10^{-19} \times \sin 90} = 4.2 \times 10^{-2} m = 4.2 cm$

Ans12) $B = 6.5 \times 10^{-4}$ T.

$e = 1.6 \times 10^{-19}$ C

$m_e = 9.1 \times 10^{-31}$ kg.

$v = 4.8 \times 10^{6}$ m/s.

$r = 0.042$ m.

Angular frequency of e^- $(\omega) = 2\pi\nu$

A/q

$$evB = \frac{mv^2}{r}$$

$$\nu = \frac{Be}{2\pi m}$$

$$= \frac{6.5 \times 10^{-4} \times 1.6 \times 10^{-19}}{2 \times 3.14 \times 9.1 \times 10^{-31}}$$

$= 18.2 \times 10^{6}$ Hz or 18 MHz

Ans13) a) $n = 30$

$r = 0.08$ m

Area of coil $= \pi r^2 = \pi(0.08)^2 = 0.0201$ m^2

$I = 6$A

$B = 1$T

$\theta = 60°$.

Counter-Torque applied is equal to,

$T = nIBA\sin\theta$.

$= 30 \times 6 \times 1 \times 0.0201 \times \sin 60°$

$= 3.133$ Nm

Ans13) b). It can be inferred from the relation that magnitude of applied torque is not independent on the shape of the coil. It depends upon the area of the coil. Hence, the answer would not change if circular coil is replaced by planar coil.

Ans14) Radius of coil X; $r_1 = 16cm = 0.16m$

" " " Y, $r_2 = 0.1m$

$n_1 = 20$

$n_2 = 25$

$I_1 = 16A$

$I_2 = 18A.$

$B_1 = \frac{\mu_0 n_1 I_1}{2r_1} = \frac{4\pi \times 10^{-7} \times 20 \times 16}{2 \times 0.16} = 4\pi \times 10^{-4} T$. (towards East)

$B_2 = \frac{\mu_0 n_2 I_2}{2r_2} = \frac{4\pi \times 10^{-7} \times 25 \times 18 \times 100}{2 \times 10} = 9\pi \times 10^{-4} T$ (towards West)

Net magnetic field,

$B = B_2 - B_1 = (9\pi - 4\pi) \times 10^{-4} T$

$= 5 \times 3.14 \times 10^{-4} T$

$= 1.57 \times 10^{-3} T$ (towards West).

Ans15) $B = 100 \times 10^{-4}$ T

$n = 1000$ turns per m

$I = 15$ A

$\mu_0 = 4\pi \times 10^{-7}$ Tm A^{-1}

$B = \mu_0 n I$

$\therefore nI = \frac{B}{\mu_0} = \frac{100 \times 10^{-4}}{4\pi \times 10^{-7}} = 7957.74 \approx 8000$ A/m

If length of coil is taken as 50 cm, radius 4 cm, no of turns = 400 and current = 10A then these values are not unique for given purpose

Ans16) a) Magnetic field at centre, x = 0.

$\therefore B = \frac{\mu_0 I R^2 N}{2R^3} = \frac{\mu_0 I N}{2R}.$

(b) Doubt

Ans17) $r_1 = 0.25$ m

$r_2 = 0.26$ m

$N = 3500$

$I = 11$ A.

a) Magnetic field outside a toroid is 0

b) " " Inside the core of a toroid is given by the relation,

$B = \frac{\mu_0 N I}{l}$ | $l = 2\pi\left(\frac{r_1 + r_2}{2}\right)$

$l = \pi(0.25 + 0.26) = 0.51\pi$

$B = \frac{4\pi \times 10^{-7} \times 3500 \times 11}{0.51\pi} = 3 \times 10^{-2}$ T.

c) Magnetic field in the empty space surrounded by toroid is zero.

Ans18) a) Initial velocity of a particle is either parallel or anti-parallel to the magnetic field. Hence, it travells along straight-path without suffering any deflection in the field.

b) Yes, the final speed of the charged particle will be equal to its speed. This is because magnetic force can change the direction of velocity but not its magnitude.

c) An e^- travelling from west to East enters a chamber having a uniform electrostatic field in north-South direction. This moving e^- can remain undeflected ~~[illegible]~~ If the electric force acting on it is equal and opposite of magnetic field. Magnetic force is directed toward south. Acc^n to fleming's left hand rule, magnetic field should be applied in vertically downward

Ans19) Centripetal force $= \frac{mv^2}{r}$

$\therefore evB = \frac{mv^2}{r}$

$r = \frac{mv}{Be}$ ① also, $v = \sqrt{\frac{2eV}{m}}$ ⑪ $\left(eV = \frac{1}{2}mv^2\right)$

From eq^n ① and ⑪.

$r = \frac{m}{Be}\sqrt{\frac{2eV}{m}} = \frac{9\times10^{-31}}{0.15\times1.6\times10^{-19}}\left(\frac{2\times1.6\times10^{-19}\times2\times10^{3}}{9\times10^{-31}}\right)^{1/2}$

$= 1.01\times10^{-3}m \approx 1mm$

Ans19) (b) When the field makes an angle θ of 30°

$v_1 = v\sin\theta$

$\Rightarrow r_1 = \frac{mv_1}{Be} = \frac{mv\sin\theta}{Be} = \frac{9\times10^{-31}}{0.15\times1.6\times10^{-19}}\left(\frac{2\times1.6\times10^{-19}\times2\times10^{3}}{9\times10^{-31}}\right)^{1/2}$

$= 0.5\times10^{-3}\,m$

$= 0.5\,mm.$

Hence, e^- has helical trajectory of radius 0.5mm

Ans20) $B = 0.75T$

$V = 15KV = 15\times10^{3}V$ ← Accelarating voltage.

$E = 9\times10^{5}\,V/m$

Kinetic Energy of $e^- = eV$

$\Rightarrow \frac{1}{2}mv^2 = eV$

$\frac{e}{m} = \frac{v^2}{2V}$ — (I)

∵ Particle remain undeflected.

∴ $Ee = evB$

$v = \frac{E}{B}$ — (II)

$\frac{e}{m} = \frac{1}{2}\left(\frac{\left(\frac{E}{B}\right)^2}{V}\right) = \frac{E^2}{2VB^2} = \frac{(9\times10^{5})^2}{2\times15000\times(0.75)^2} = 4.8\times10^{7}\,C/kg.$

$\frac{e}{m}$ is equal to value of ~~dra~~ deutron or deuterium ions.